Functional Coverage (Dragos)

- What is FC4SC
- Coverage definition API
- Coverage options and sampling API
- Output & visualisation
- Documentation
- What can be improved
- Basic mechanisms demonstrated on SFIFO example (Stephan)

What is FC4SC (1)

- C++11 header only library:
  - built from scratch, with no 3rd party library dependencies
  - Based on IEEE 1800 - 2012 SystemVerilog Standard
  - https://github.com/amiq-consulting/fc4sc
- Features:
  - Coverage model construction
  - Coverage sampling control & options
  - Runtime coverage queries
  - Coverage database saving

What is FC4SC (2)

Coverage DB management tools

1) Coverage DB visualisation tool (JavaScript):
   fc4sc/tools/gui/index.html

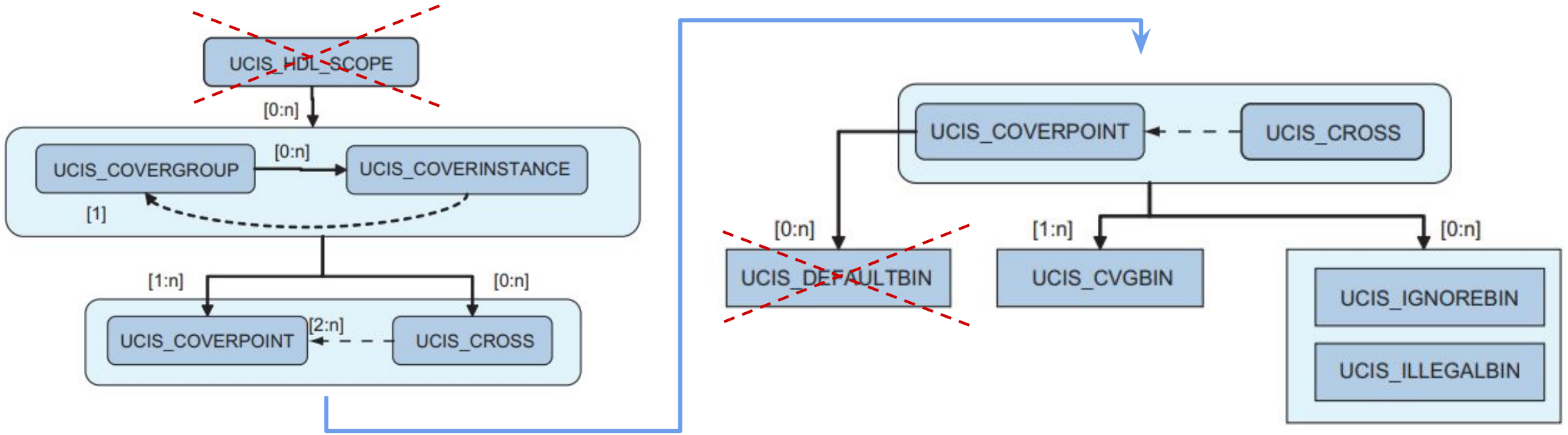
1) Coverage DB merge tool (Python):
   fc4sc/tools/coverage_merge/merge.py

Easy to use; just

#include “fc4sc.hpp”

Coverage definition API: overview

- Follows UCIS DB coverage data model:
- Elements: bin, coverpoint, cross, covergroup



Crossed out elements are not currently part of the implementation

Coverage definition API: covergroup

```
class cvg_ex: public covergroup
{
public:
   CG_CONS(cvg_ex) {
    /*user code*/
   }
};
```

```
cvg_ex cg1("cg1");

cvg_ex cg2("cg2");
```

```
#define CG_CONS(type, args...) \
  using covergroup::sample; \
  type(std::string inst_name = "", ##args) : fc4sc::covergroup(#type, __FILE__, __LINE__, inst_name)
```

Coverage definition API: coverpoint (1)

- Register the coverpoint into the covergroup
- Bind sample expression & condition
- Add bins

This code is part of the user's covergroup definition

Name & data type

Sample expression & condition

```
COVERPOINT(int, datacp, data*2, flag!=0)
{
    // bin definitions
};
```

Coverage definition API: bins (basic)

```
bin<int>("less_than_8",
    1,
    interval(2, 3),
    interval(7, 5)
);

illegal_bin<int>("10", 10);
ignore_bin<int>("100", 100);
```

Multiple bin types → different sampling behavior

- ! name (std::string) → first argument is **mandatory**
- ! values / intervals → leading arguments **at least one**

Coverage definition API: bins (complex #1)

```
// 2 bins inside [0:255]
bin_array<int>("split",
    2,
    interval(0, 255)
);
```

Expands to multiple separate bins inside the coverpoint

```
bin<int>("split[0]", interval(0, 128)),
bin<int>("split[1]", interval(129, 255))
```

Coverage definition API: bins (complex #2)

```
auto fibonacci = [](size_t N) -> std::vector<int>
{
  int f0 = 1, f1 = 2; // initialize start number
  std::vector<int> result(N, f0);
  // calculate following fibonacci numbers
  for (size_t i = 1; i < N; i++) {
   std::swap(f0, f1);
   result[i] = f0;
   f1 += f0;
  }
  return result;
};
COVERPOINT(int, bin_array_cvp, value) {
   bin_array<int>("fib", fibonacci(5))
};
```

```
bin<int>("fib[0]", 1),
bin<int>("fib[1]", 2),
bin<int>("fib[2]", 3),
bin<int>("fib[3]", 5),
bin<int>("fib[4]", 8)
```

Coverage definition API: bins + coverpoint

➔ *bins are added at the coverpoint definition*

```
COVERPOINT(int, datacp, data * 2, flag != 0)
{
   illegal_bin<int>("illegal_3", 3),
   ignore_bin<int>("ignore_2", 2),
   bin<int>("four", 4),
   bin<int>("other", 11, interval(5,10), interval(20,30))
};
```

The order and number of bins are arbitrary!

Coverage definition API: cross

```
class cvg_ex: public covergroup {
public:
  CG_CONS(cvg_ex) {
   /*user code*/
  }

  auto cvp1_x_cvp2 = cross<int,int>(this, "cross", &cvp1,&cvp2);

  COVERPOINT(int, cvp1, data1) {
    bin<int>("zero", 0),
    bin<int>("positive", 1, 2)
  };

  COVERPOINT(int, cvp2, data2) {
    bin<int>("zero", 0),
    bin<int>("negative", -1, -2)
  };
};
```

Coverage options & sampling API (1)

Public Member Functions

	cvg_option () Sets all values to default.

Public Attributes

uint	**weight**
uint	**goal**
std::string	**comment**
uint	**at_least**
uint	**auto_bin_max**
bool	**detect_overlap**
uint	**cross_num_print_missing**
bool	**per_instance**
bool	**get_inst_coverage**

Friends

std::ostream &	**operator<<** (std::ostream &stream, const **cvg_option** &inst) Prints option in UCIS XML format.

Public Member Functions

	cvg_type_option () Sets all values to default.

Public Attributes

uint	**weight**
uint	**goal**
std::string	**comment**
bool	**merge_instances**

Coverage options & sampling API (2)

Public Member Functions

	cvp_option () Sets all values to default.

Public Attributes

uint	**weight**
uint	**goal**
std::string	**comment**
uint	**at_least**
uint	**auto_bin_max**
bool	**detect_overlap**

Friends

std::ostream &	**operator<<** (std::ostream &stream, const **cvp_option** &inst) Prints option in UCIS XML format.

Public Member Functions

	cross_option () Sets all values to default.

Public Attributes

uint	**weight**
uint	**goal**
std::string	**comment**
uint	**at_least**
uint	**cross_num_print_missing**

Friends

std::ostream &	**operator<<** (std::ostream &stream, const **cross_option** &inst) Prints option in UCIS XML format.

Coverage options & sampling API (3)

Public Member Functions

virtual void	**to_xml** (std::ostream &stream) const =0 Function to print an item to UCIS XML.
virtual void	**sample** ()=0
virtual	**~api_base** ()

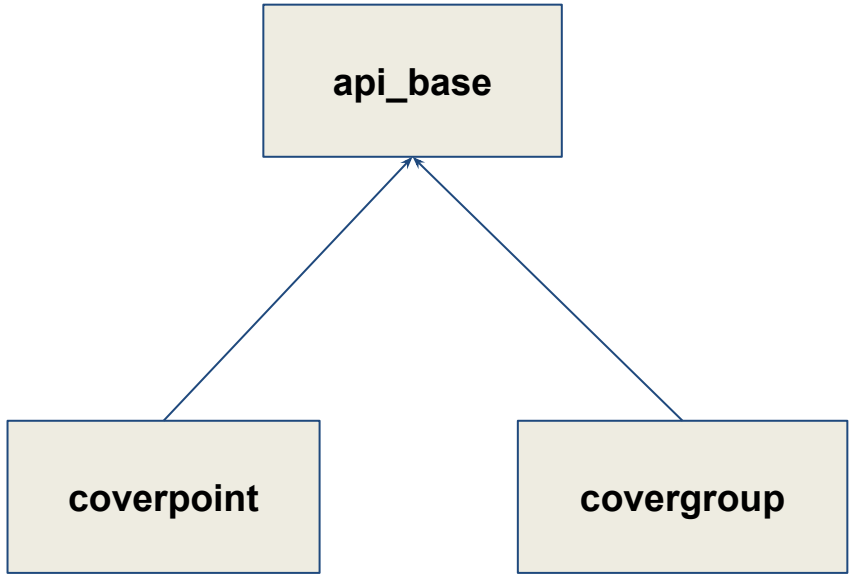
Coverage API

API for getting and controlling coverage collection at run time

virtual double	**get_inst_coverage** () const =0 Returns the coverage associated with this instance.
virtual double	**get_inst_coverage** (int &hit, int &total) const =0 Returns the coverage associated with this instance.
virtual void	**set_inst_name** (const std::string &new_name) Changes the name of the instance.
virtual void	**start** ()=0 Enables sampling on this instance.
virtual void	**stop** ()=0 Stops sampling on this instance.

Public Attributes

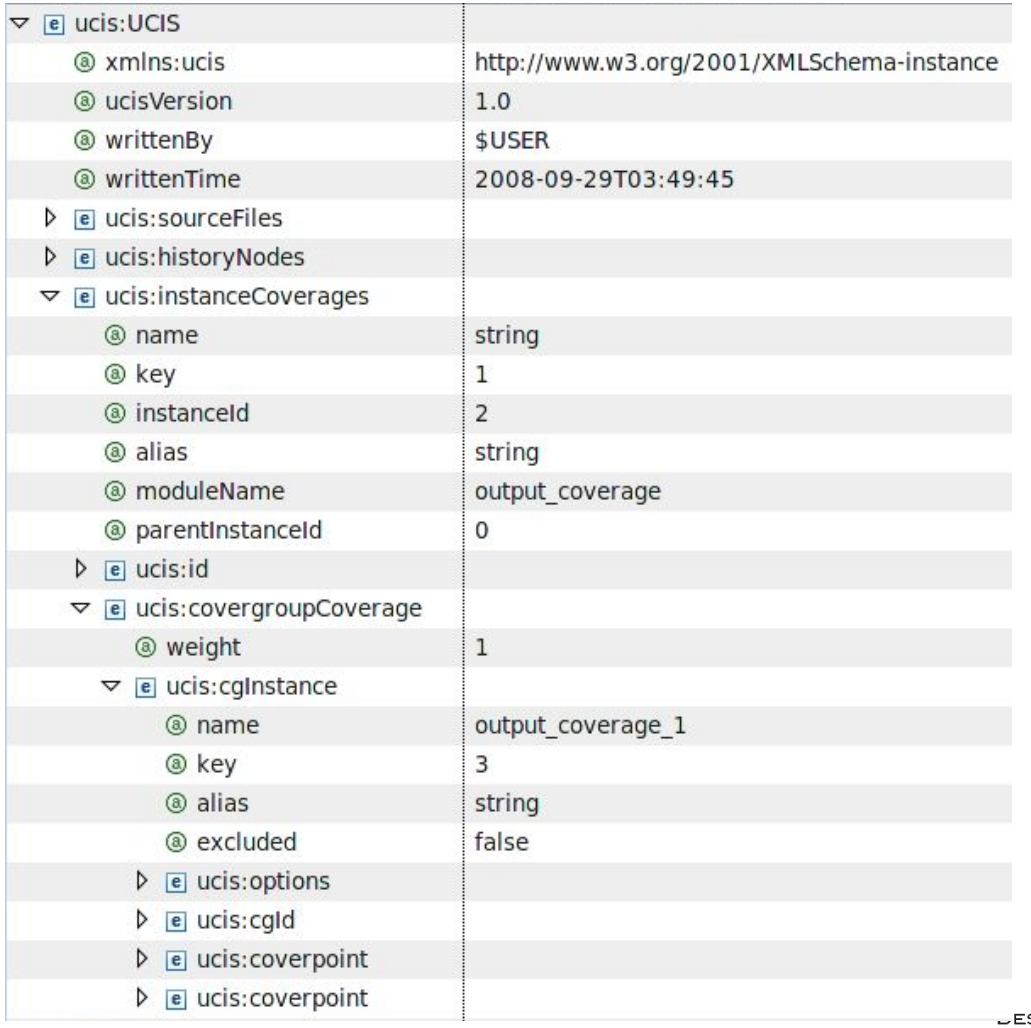
std::string	**name**



Output & visualization

Generate output (from code):

fc4sc::global::coverage_save("out.xml");



ucis:UCIS	
xmlns:ucis	http://www.w3.org/2001/XMLSchema-instance
ucisVersion	1.0
writtenBy	$USER
writtenTime	2008-09-29T03:49:45
ucis:sourceFiles	
ucis:historyNodes	
ucis:instanceCoverages	
name	string
key	1
instanceId	2
alias	string
moduleName	output_coverage
parentInstanceId	0
ucis:id	
ucis:covergroupCoverage	
weight	1
ucis:cgInstance	
name	output_coverage_1
key	3
alias	string
excluded	false
ucis:options	
ucis:cgId	
ucis:coverpoint	
ucis:coverpoint	

Documentation

1) Doxygen
2) PDF User guide
3) github.com/amiq-consulting/fc4sc repository releases notes

What can be improved

- Coverpoint definition API
- Custom types parametrization for *bin*, *coverpoint*, *cross*?
- Add default bins
- Add cross bins filtering
- Add cross sampling condition
- Add coverage model visitor
- Better UCIS DB support
- More support of coverage options